

# Technology use by people with intellectual and developmental disabilities to support employment activities: A single-subject design meta analysis

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**Abstract.** *Objectives:* Technology has the potential to improve employment and rehabilitation related outcomes for persons with disabilities. The purpose of this study was to examine the impact of technology use on employment-related outcomes for people with intellectual and developmental disabilities.

*Study design:* A comprehensive search of the literature pertaining to technology use by people with intellectual disabilities was conducted, and a single-subject design meta analysis was conducted for a subset of those studies, which focused on employment and rehabilitation related outcomes.

*Results:* The use of technology to promote outcomes in this area was shown to be generally effective, in particular when universal design features were addressed.

*Conclusions:* Technology has the potential to enable people with intellectual and developmental disabilities to achieve more positive employment and rehabilitation outcomes. It is important to focus on universal design features important to persons with cognitive disabilities, and there is a need for more research in this area.

**Keywords:** Technology, mental retardation, intellectual disabilities, meta analysis, employment outcomes

## 1. Introduction

Employment is an area of both great importance and of considerable dependency for many people with intellectual and developmental disabilities and technology use has become an important support to enable them to gain and maintain employment. As early as 1987, Gaylord-Ross identified the use of instructional

technology as an important element in successful employment efforts [8]. While the use of technology for job training and job skill development, as emphasized by Gaylord-Ross, is still important for people with intellectual and developmental disabilities, the emphasis on technology use in this life domain has expanded considerably in the nearly 20 years since to include the use of technology to provide on-the-job supports and real time assistance to workers with cognitive and multiple disabilities. In addition, technology is being used to teach complex job related skills that do not pertain to a specific task or activity, but rather the acquisition of positive behavioral and social skills necessary for successful employment [16,21].

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More recent examinations of technology use to improve vocational outcomes for individuals with intellectual and developmental disabilities have generally addressed two areas; improvement of specific job task performance while minimizing human supports (i.e. job coaches, supervisors) and improvement of social and behavioral skills related to work settings. Such applications have, generally, yielded positive vocational outcomes [2,5,14,15,22].

Not surprisingly, computer-based systems, such as Internet and palmtop PC based devices with specialized interfaces, have been applied to support vocational task attainment. For example, Davies et al. [5] evaluated a system that was designed to provide vocational supports for individuals with intellectual disabilities. This system, which provided self-directed audio and video prompts on a Windows CE based handheld computer, was evaluated in an employment setting to determine its utility for improving task accuracy and independence on two different vocational assembly tasks: folding pizza boxes and packaging a commercial software product. Ten individuals with intellectual disabilities performed each task with and without the presence of the technology system. After initial training on both the task and use of the computer system, participants used the specialized software to follow step-by-step picture and audio prompts at their own pace. Results indicated that the computerized prompting system significantly improved task performance. In addition, these gains were achieved with significantly greater independence, as measured by the amount of assistance required from a job coach to complete each task. Third, participants expressed positive reactions to as well as preference for using the specialized prompting system.

Similarly, Furniss et al. [7] conducted a study in which a portable, computerized prompting system was evaluated in real work settings. In this study, a portable computer system was used to present pictorial instructions and audio prompts of each step in a number of work tasks. The computer used had a color screen, a palmtop keyboard, 8 Mb of RAM, a 33 Mhz CPU, and a radio communication system for alerting job coaches when help was needed. While researchers reported that results were somewhat mixed, overall they suggested that the portable computer-aided prompting system was effective in enabling participants to achieve higher task accuracy scores following a brief period of intensive training, particularly for more complex tasks that were new to the individuals.

Furniss and colleagues [7] summarized five other studies, including the above-cited study, in which

evolving versions of this same portable computerized prompting system were used to improve performance accuracy for individuals with severe disabilities. These studies collectively demonstrated that a computerized prompting system was more effective than using pictorial instructions presented in booklets, that users repeatedly preferred use of the computerized system to picture booklets, and that the computerized system was usable in real work settings. The authors also noted that effective use of the system required job coaches to acquire competence in systematic instruction as well as basic computer skills. For example, setup of the prompts and timing information is performed on a desktop PC and then downloaded to a "player" application on the portable computer, and job coaches need basic computer skills to manage these activities. In addition to end users with severe disabilities preferring the technology supports, Furniss and colleagues [7] reported that caregivers and co-workers viewed the use of the technology very positively.

Although evaluations of technology applications to promote employment related outcomes for persons with intellectual and developmental disabilities have been limited, the evidence is mounting that technology systems, like those discussed by Davies et al. and Furniss et al., which are designed specifically to address the support and user interface needs of individuals with cognitive disabilities, can improve vocational outcomes for many individuals. To provide a more systematic evaluation of the impact of technology use on rehabilitation and employment related outcomes for people with intellectual and developmental disabilities, we conducted a meta-analysis of single-subject design studies that have been published in the past quarter century.

## 2. Method

### 2.1. Procedure

As part of a federally funded project to examine the utilization of technology by people with intellectual disabilities, we conducted an extensive search for articles published in peer-reviewed journals that addressed the use of technology by people with intellectual disabilities. An extensive search of the PsychINFO and ERIC databases for articles published from 1977 to 2003 was conducted using two key words (mental retardation, intellectual disabilities) with a combination of other key words, listed in Table 1.

Table 1  
Keywords for Literature Search

Computer
Computer Use
Technology
Technology Use
Assistive Technology
Adaptive Technology
Instructional Technology
Electronic Technology
Information Technology
Assistive Devices
Augmentative Communication
Alternative Communication

At this juncture we were interested in cataloging all articles meeting the key word search criteria, and thus initial information (article title, authors names, journal name, volume number, and page numbers) were entered into a Microsoft Access database. Each article was then obtained and reviewed to gain more information. A total of 411 articles that fit the search criteria were obtained and information from each was coded. Additional information added to the database for these 411 articles included keywords for each article, information on the type of technology used, the functional use area to which the technology was applied (communication, mobility, environmental control, daily living, community inclusion, employment, education, recreation/leisure), level and type of cognitive or physical impairment, and research design. We also evaluated the degree to which any issue of universal design (equitable use, flexible use, simple and intuitive use, perceptible information, tolerance for error, low physical/cognitive effort, size and space) was discussed or identified as features of the device evaluated in the study.

Of these 411 articles, 275 were data based, and the remaining 136 were opinion articles or position statements. Of the 275 data based articles, 251 were quantitative (group design, single subject design, literature reviews) and 24 were qualitative. Of the quantitative studies, 110 implemented a single subject design. From the original sample of 411 articles, there were, however, only 30 that explicitly addressed employment-related needs. Of those 30, 13 were single subject design studies, and it is with this group of studies that we conducted the meta-analysis. Studies included in the meta analysis were [1,3,6,9,10–13,16,17,20,22,23].

Each of these 13 studies was examined for treatment efficacy to calculate the percentage of nonoverlapping data (PND [19]) and percentage zero data (PZD [18]) metrics as indices of behavior change. PND is a measure of the proportion of nonoverlapping data between baseline and treatment phases. It is calculated by di-

viding the number of treatment data points that fall below the lowest baseline data point by the total number of data points in the treatment phase, multiplied by 100 [19]. PND scores can range from 0 to 100%, with higher scores indicating more effective treatments. Scotti et al. [18] suggested specific criteria to evaluate the practical implication of PND values, with PND scores ranging from 50% to 80% identifying the treatment as questionable, scores greater than 80% and less than 99% as fair, and scores greater than 99% as highly effective. When baseline data reaches a floor level of performance (i.e., zero), this will result in a PND of zero, which in some circumstances may not be an appropriate representation of treatment effects. For this reason, Scruggs and Mastropieri [19] hold that when not more than three, nor less than 33 1/3% of total baseline data points reach a floor level, PND cannot be calculated.

PZD is a companion measure of the degree an intervention reduced and maintained a behavior at zero levels. It is calculated by identifying the first data point in the treatment phase that reached zero and calculating the percentage of data points from that point onward which remained at zero level [18]. Percentage zero data scores also range from 0 to 100% with higher scores indicating more effective treatments. Scotti et al. [18] suggested specific criteria to evaluate the practical implication of PZD values, with PZD scores under 18% identifying the treatment as ineffective, scores from 18% to 54% as questionable, scores from 55% to 80% as fairly effective, and any score over 80% as highly effective range.

The 13 single subject design studies selected for inclusion in the meta analysis involved a total of 42 unique study participants with intellectual and developmental disabilities. These participants ranged in age from 12 to 37 (Mean age = 20.23, SD = 6.89), and encompassed vocational and rehabilitation-related activities for transition-age students through adulthood. Articles were coded to record each study participant's age, gender, diagnosis, setting, and, when available, IQ score. IQ scores were reported for only for 30 participants and ranged from 28 to 72 (Mean IQ Score = 42.86, SD = 11.75). There were 22 males and 20 females in the sample. Males ranged in age from 14 to 34 (Mean age = 18.52, SD = 4.51) and IQ scores from 28 to 72 (Mean IQ Score = 44.68, SD = 11.76). Females ranged in age from 12 to 37 (Mean age = 22.12, SD = 8.54) and IQ scores from 29 to 72 (Mean IQ Score = 40.78, SD = 11.82).

## 2.2. Analyses

PND and PZD scores were calculated for each unique treatment phase and its preceding baseline identified in the studies. For studies that utilized an ABAB design with one or more participants, only treatment phases with a baseline preceding them were analyzed, but each baseline and treatment phase were treated as a unique case. In all, there were 95 unique cases resulting in PND scores. However, because the vast majority of these studies examined the impact of the use of technology on increasing vocationally relevant behavior, instead of using technology to reduce problem behavior in vocational or work environments or situations, there were only two cases in which the PZD score was calculated. Thus, we conducted analysis only for PND scores across each unique intervention and participant variable.

Data were summarized and reported in tabular and graphic formats. Based on recommendations by Scotti et al. [18], non-parametric procedures were used to analyze for effects of the various intervention and participant characteristics on PND scores. To examine the effect of individual characteristics and universal design features on study outcomes, separate Kruskal-Wallis tests were conducted, with PND scores as dependent variables.

Reliability of PND scores was assessed by having two raters independently calculate PND scores for each unique treatment phase and its preceding baseline; agreement was scored when the first and second coders obtained identical PND and PZD scores for each unique phase. Reliability was calculated by dividing the number of agreements by the number of agreements + disagreements, multiplied by 100. This calculation was done for all single subject design studies, not simply those focusing on employment outcomes.

## 3. Results

Coders agreed completely on 100% for eight of the single subject design articles, with the remaining articles reaching 90% agreement or above. The coders came to consensus on the remaining data point computations to ensure the most accurate scores for entry into the analysis.

The mean Percentage Non-Overlapping Data (PND) score for all 95 cases was 93% ( $SD = 0.14$ ), indicating that the use of technology by persons with intellectual or developmental disabilities on employment or

Table 2  
Application of universal design principles

Universal design principle	% Yes	% No
Equitable Use	14	86
Flexible Use	28	72
Simple Intuitive Use	24	76
Perceptible Information	16	84
Tolerance for Error	20	80
Low Phys/Cog Effort	0	100
Size and Space	0	100

rehabilitation related outcomes resulted in “Fair” effects. There were no significant differences on PND scores by level of severity of intellectual disability (mild/moderate vs. severe/profound) on the Kruskal-Wallis test for PND scores. These two groups had similar PND scores, with participants with mild/moderate impairments ( $n = 42$ ) having an average PND score of 94% ( $SD = 0.11$ ), and participants with severe/profound disabilities ( $n = 53$ ) having an average PND score of 92% ( $SD = 0.16$ ).

Table 2 provides percentages as to whether universal design principles were incorporated into the technology device or application. Forty-two percent of the cases had no UD feature identified, 15% had one UD feature incorporated, 40% had two, and 3% had three UD features identified. We formed two groups around UD features, the first in which no UD features were identified ( $n = 40$ ), and the second if more than one UD feature was identified ( $n = 41$ ). A Kruskal-Wallis test for PND scores based on UD use found significant differences between these groups ( $p = 0.035$ ), with participants in the group incorporating universal design features having an average PND score of 97% ( $SD = 0.08$ ), and studies not addressing universal design features having an average PND score of 91% ( $SD = 0.18$ ).

## 4. Discussion

The results of this single-subject design meta-analysis confirm the indications in the literature that technology use can contribute to more positive vocational and employment related outcomes for youth and adults with intellectual and developmental disabilities. The range of technology devices included in the meta-analysis was wide, from audio prompting devices [1,6,14,22,23], video assisted training [16], palmtop [11], and desktop [9,10,12,13], computers, augmentative and alternative communication [17,20]. There were too few studies examining any one type of technology to warrant analysis by that factor, but there is a need to

examine the impact of particular types of technology on vocational-related outcomes.

Similarly, the technology was applied to address a wide range of vocational and employment related outcomes, from work-related social skills [16], task sequencing and transition skills [22], vocational task performance and completion [6,9–12,14], food preparation skills [23], vocational assembly skills [1], requesting assistance on a vocational task [20], general cleaning skills [3], and computer-use itself [13].

The variety of technologies and activities to which these technologies were applied speak to the significant potential that technology can play in shaping positive employment and vocational outcomes. The overall PND of 93% fell short of the 99% suggested by Scotti, et al. as indicating highly effective treatments, but fell nonetheless in the upper half of the “Fair” efficacy range.

That PND scores differed significantly between studies that indicated the presence of universal design features and those that did not illustrates the critical importance of ensuring that technology is designed to meet the unique needs of people with intellectual and developmental disabilities. When devices are designed taking into account all aspects of universal design, people with intellectual disabilities will benefit. There are, however, several such features that might be particularly important for this population. First, devices that abide by the *Flexibility in Use* principle inherently accommodate for use by a wider range of individual preferences and abilities. This includes providing options that accommodate for users’ accuracy and precision, and adapt to a user’s pace. For example, computer programs providing multiple input and output options (auditory, visual, icon, etc.) fit this category, as do telephones that have larger buttons with more space between numbers [4]. Issues of simplicity and intuitiveness of use, another principle, are obviously important for people with mental retardation. Many devices are overly complex and operate counter to users’ expectations. Universally designed devices also typically provide some supports (prompting, graphic, visual, or audio directions) for use. The principle of perceptible information requires not only that information needed to operate the device be easily seen, but also that such information be provided in multiple modes, with redundant presentation of information.

There are a number of limitations that must be taken into account when interpreting these results. First, there were relatively few studies overall and the outcomes of the meta-analysis would have been stronger with a

larger sample base. Nonetheless, the level of analysis in this meta-analysis was the unique intervention event, and not the study, and there were 42 participants in the study resulting in 94 cases for analysis, which we believe is of sufficient size. That many of the studies were older and tested only very simple technology supports (e.g., audio prompting) illustrates the need to engage in more research looking at these issues for this population. Finally, the studies ranged from vocational preparation to simulated work to real work settings, making it difficult to generalize to any one or the other of these settings.

Perhaps the most compelling finding was that there are still relatively few empirical evaluations of technology use by people with intellectual and developmental disabilities in the literature. Given the promising findings from this study, it seems warranted to focus more research and development efforts on this population.

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